

## ORIGINAL ARTICLE

## Road traffic injuries in the elderly

W Y Yee, P A Cameron, M J Bailey

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See end of article for  
authors' affiliations

Correspondence to:  
Dr W Y Yee, Emergency  
Physician, Emergency  
Department, Changi  
General Hospital, 2, Simei  
Street 3, 529889,  
Singapore; wee\_yee\_lee@  
cgh.com.sg

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**Objective:** Elderly victims of motor vehicle collisions are increasing with the aging population. This study aimed to investigate the injury pattern of elderly victims involved in motor vehicle collisions.

**Methods:** This was a retrospective study using data from the Victorian State Trauma Outcome Registry and Monitoring Group (VSTORM) from June 2001 to July 2003, Australian Bureau of Statistics year 2001 population estimates, and Victoria Transport Accident Commission year 2001 total road death toll. Elderly victims were defined as age 65 and above. Comparison of fatality rates and general injury patterns for the elderly and young victims was undertaken.

**Results:** The total fatality rate of the elderly group was almost double that of the younger group. The elderly victims had a higher rate of chest injuries (23.42% v 18.17%;  $p=0.003$ ). The three most common chest injuries of the elderly victims were rib fractures (23.58%), flail chest (9.55%), and sternum fractures (5.97%). Elderly chest injured patients also had longer intensive care unit stay compared with the younger group (7.96 days v 5.31 days;  $p=0.048$ ).

**Conclusions:** Elderly victims of motor vehicle collisions have a higher risk of chest injuries, especially of chest wall injuries. Age specific injury patterns are important in determining primary and secondary prevention strategies.

The rising proportion of the population aged 65 and older is increasing demands on the healthcare system and causing concern in many countries. From 1992 to 2002, the proportion of people aged 65 years and over in the United States for example, grew 27% faster than that of the total population.<sup>1</sup> The elderly are more likely to use healthcare facilities for both medical and traumatic illnesses. Different rates and patterns of injury in the elderly result in poorer outcomes in this group. There are potential opportunities for primary and secondary injury prevention strategies to improve morbidity and mortality in the elderly, particularly those serious injuries resulting from road traffic collisions.

With the aging population, there has been a corresponding increase in the total number of older road users, either as vehicle occupants or as pedestrians. Preusser *et al* showed that drivers aged 65–69 years were 1.29 times more at risk of being involved in fatal crashes and drivers aged 85 and older were 3.74 times more at risk when compared to drivers aged 40–49.<sup>2</sup> Older drivers have a major impact on other road users, increasing the risk of morbidity and mortality of their passengers and other passenger vehicles' occupants.<sup>3–4</sup> Elderly collision victims have an increased risk of fatality because of increased fragility.<sup>5</sup> In the US, Lyman has projected a 178% increase in road crashes involving the elderly and a 155% increase in fatalities involving the elderly. This will account for about 40% of the expected increase in all road crashes and more than 50% of the expected increase in fatalities.<sup>6</sup>

Similar aging trends have been seen in the state of Victoria, Australia from 1996 to 2001. The median age of the population had increased from 33 to 35 years. While the proportion of people aged 65 years and over increased marginally from 12% to 12.7%, the proportion of people aged 14 and less decreased from 21.2% to 20.4%.<sup>7</sup> In the year 2003, there was a total of 330 fatalities on the roads, 6.71 deaths per 100 000 people in the population.<sup>8</sup> Older drivers (aged 65+) represented 13% of license holders but accounted for 16% of fatalities and 10% of serious injuries. In terms of fatalities per kilometre traveled, older drivers were seven times more likely to be killed than the lowest risk age group,

45–54 year olds. Older pedestrians represent 13% of the population, but account for 36% of fatalities and 15% of serious injuries.<sup>9</sup>

Many countries have seen growing numbers of older road users and greater numbers of elderly present to the emergency department as the result of motor vehicle collisions. Few studies have examined the injury pattern in elderly victims despite the fact that the elderly have a higher risk of fatality. The aim of this study was to investigate the differences in injury pattern for elderly patients involved in motor vehicle collisions. This could be helpful in guiding prevention and management strategies in this age group.

## METHODOLOGY

This is a retrospective study carried out using data collected by the Victorian State Trauma Outcome Registry and Monitoring Group (VSTORM).

## Setting

The state of Victoria, Australia has a population of 4.9 million people with two thirds of its population in the metropolitan Melbourne. It has two adult and one paediatric major trauma centres.

## Data

The Victorian State Trauma Registry (VSTR) database collects standardised trauma data from the hospitals for all major traumas in Victoria.<sup>10</sup> All Victorian hospitals other than one health service provide these data. It is estimated that during the period of study, more than 90% of the major trauma patients were included. In the VSTR, patients meeting the following criteria were included:

**Abbreviations:** AIS, Abbreviated Injury Score; GCS, Glasgow Coma Score; ICU, intensive care unit; ISS, Injury Severity Score; TAC, Transport Accident Commission; TRISS, Trauma and Injury Severity Score; VSTORM, Victorian State Trauma Outcome Registry and Monitoring Group; VSTR, Victorian State Trauma Registry.

1. All deaths after injury.
2. All patients admitted to an intensive care unit (ICU) or high dependency area for more than 24 hours and are mechanically ventilated after admission.
3. Significant injury to two or more Injury Severity Score (ISS) body regions (corresponding to Abbreviated Injury Score (AIS) AIS>2 in two or more body regions) or ISS>15.
4. Urgent surgery (within 24 hours of injury) for intracranial, intrathoracic, or intraabdominal injury, or fixation of pelvic or spinal fractures.
5. Electrical injuries, drowning, asphyxia included if admitted to an ICU and have mechanical ventilation greater than 24 hours.
6. All patients with injury as principal diagnosis whose length of stay is three days or more—*unless meet exclusion criteria*.
7. All patients, with injury as principal diagnosis, transferred or received from another hospital for further emergency care or admitted to a high dependency area—*unless meets exclusion criteria*.

The exclusion criteria were:

1. Isolated fractured neck of femur.
2. Isolated upper limb joint dislocation, shoulder girdle dislocation (unless associated with vascular compromise) and toe/foot/knee joint dislocation—*unless meets inclusion criteria 1, 2, or 4*.
3. Isolated closed, limb fractures only (for example, fractured femur, Colles fracture)—*unless meets inclusion criteria 1, 2, or 4*.
4. Isolated injuries distal to the wrist and ankle only (for example, finger amputations)—*unless meets inclusion criteria 1, 2, or 4*.
5. Soft tissue injuries only (for example, tendon and nerve injury and uncomplicated skin injuries)—*unless meets inclusion criteria 1, 2, or 4*.
6. Burns to less than 10% of the body—*unless meets inclusion criteria 1, 2, or 4*.

Data were gathered from patients injured in motor vehicle collisions from June 2001 to July 2003. The following data were used for the study: biodata of the patient, prehospital information, presenting physiological data, ICD10 diagnosis codes (the International Classification of Diseases, 10th Revision, Australian Modification, which is based on the official version of the World Health Organization's 10th Revision), operative procedures, length of stay in the ICU and hospital, and outcome of the patient. Injury scoring according to the AIS 1990 revision was performed by VSTORM. Other calculated data generated include the Revised Trauma Score (RTS) calculated from emergency department arrival physiology, ISS, and the revised Trauma Score and Injury Severity Score (TRISS). TRISS incorporates the physiological elements of the RTS and the anatomical elements of the ISS. Additionally, patient age is included for a more precise assessment of the probability of survival (Ps).<sup>11</sup> The coefficients were derived from the North American Major Trauma Outcome Study 1995.

Population estimates for the year 2001 were obtained from the Australian Bureau of Statistics website. The 2001 Census Basic Community Profile and Snapshot were used.<sup>12</sup> This census count excluded overseas visitors.

The year 2001 total road death toll was provided by The Transport Accident Commission (TAC) using Vic Roads data. The total road death toll included all death that fulfilled the following criteria: a count of fatalities arising from crashes on

**Table 1** Road fatality rate by age and sex per 100 000 population of the age segment

Age (years)	Female	Male	Total
0–24	4.02	12.04	8.12
25–44	4.06	16.20	10.00
45–64	5.10	11.54	8.29
Mean <65	4.39	13.26	8.80
≥65	12.92	18.19	15.20

a road or road related area in Victoria. Death had to be within 30 days of the date of crash and excluded suicides, off-road crashes, and natural causes (for example, heart attacks).

## Analysis

Fatality rates, expressed in per 100 000 people of their respective age and sex category, were derived from the 2001 total road death toll from TAC and the census count of 2001.

The general injury pattern was determined by comparing the variables between the young (<65 years) and the old (>65 years) including: RTS, Glasgow Coma Scale (GCS), ISS and TRISS, type of accidents involved, AIS body region involved, and the severity score of the AIS body region involved.

After the specific AIS injury region involved was identified from the general injury pattern, further analysis was performed using the injury description of the specific AIS injury region to better determine the type of injuries.

Outcome analysis looked at the mortality and morbidity rate of each AIS body regions, the length of stay in the ICU and hospital and the type of operations that the patient underwent.

## Statistics

Data analysis was performed using the SAS version 8.2. (SAS Institute Inc, Cary, NC, USA). Figures were presented in absolute number and percentages of patients or injuries. Pearson's  $\chi^2$  test was used to analyse discrete data variables and to compare proportions. The Student *t* test and Wilcoxon test was used to compare the averages for continuous data variables. A *p* value <0.05 was considered statistically significant.

## Ethics approval

The use of de-identified data in this study was approved and provided by VSTORM. VSTORM obtained full ethics committee approval from each hospital/health service contributing to the Registry before data collection in that setting.

## RESULTS

The VSTR database recorded a total of 1539 major trauma patients involved in road traffic collisions between 1 June 2001 and 31 July 2003. The young group included all patients less than 65 years with a mean age 30.5 years and the elderly group included all patients more than or equal to 65 years with a mean age of 75.8 years. There were 1361 patients in the young group and 178 patients in the elderly group.

Road fatality rates for year 2001 of Victoria are detailed in table 1. Overall, males had a higher collision rate and fatality rate than females throughout all the age groups. The fatality rate of the elderly group was almost double that of the younger group.

A comparison of the physiological factors and injury scores between the two groups showed that there was no difference between the GCS, RTS, and ISS. TRISS score was lower in the older group (old, 0.88 *v* young, 0.97; *p*<0.0001) This was

**Table 2** Collision and mortality according to type of collision involved versus age

	Collision					Mortality*				
	<65 years		≥65 years		p Value	<5 years		≥65 years		p Value
	n	%	n	%		n	%	n	%	
Motor vehicle driver	531	39.02	81	45.51	NS	43	8.10	22	27.16	<0.001
Motor vehicle passenger	269	19.76	37	20.79	NS	26	9.67	10	27.16	<0.001
Motorcycle driver	254	18.66	1	0.56	NS	19	7.48	1	100.00	†
Motorcycle passenger	15	1.10	0	0.00	NS	2	13.33	0	0.00	†
Other transport	25	1.84	1	0.56	NS	2	8.00	0	0.00	†
Bicyclist	80	5.88	6	3.37	NS	5	6.25	1	16.67	†
Pedestrian	187	13.74	52	29.21	<0.0001	32	17.11	13	25.00	NS
Total	1361	100.00	178	100.00		129	9.48	47	26.40	<0.001

\*Mortality is expressed as a percentage to the collision of the type of collision involved.

†p values were not calculated for these values as the number involved were too small.

NS, not significant.

expected because this score takes into account the age of the patient.

The types of collisions and the in-hospital mortality rates according to the collision type are shown in table 2. For elderly pedestrians who presented to the hospital after a collision, the in-hospital mortality rate was similar to the younger group. However elderly motor vehicle occupants, who survived to hospital, showed a statistically significant higher mortality rate compared to the younger group.

A patient may have multiple body regions involved in the collision. Moreover each body region may demonstrate several different types of injuries. For example, the patient may have chest, abdominal, and extremities body regions involvement by AIS classification. For chest injuries, the patient may have rib fractures, pneumothorax, and cardiac contusion. Thus analysis of the AIS body regions and type of injuries were calculated according to the injuries noted and not to the number of patients. This resulted in a larger number of cases than the total number of patients as shown in the analysis.

The elderly group had a higher rate of chest injuries while the young group had higher abdominal and facial injury rates (table 3). There were no significant differences between the severity of the injury for each AIS region between the two groups. The increased rate of chest injuries in the elderly group was mainly due to motor vehicle occupants (table 4).

In the elderly group the most common chest injuries were those involving the chest wall, (table 5) namely rib fractures (23.58%), flail chest (9.55%), and sternal fractures (5.97%). All these figures were significantly higher than that for the young group. Spinal injuries were noted to be significantly higher for the young group in both analysis of chest (21.74%,  $p < 0.001$ ) and abdominal injuries (31.46%,  $p = 0.02$ ).

The percentages of head and neck injuries and the severity of the injuries for both groups were similar, but there was a lower operative rate (old, 9.27% v young, 16.71%,  $p = 0.007$ ) for the old group. Operative rates for chest, abdomen, muscular skeletal, spine, and others were the same for both

age groups. The total length of stay in the acute hospital and ICU was not found to be different between the young and old group. However, when total ICU stay was analysed according to the AIS injury region, the old group with chest injury had a longer ICU stay compared to the younger group (old, 7.96 days v young, 5.31 days,  $p = 0.048$ ).

In-hospital mortality was higher in the old group (old, 26.40% v young, 9.49%,  $p > 0.001$ ). This did not appear to be due to injuries from a particular body region.

## DISCUSSION

Motor vehicle collisions involving elderly people have become an important problem that requires further investigation. Age in itself is an important injury risk factor, increasing the rate of injury and severity.<sup>13</sup> Our study has shown that road traffic injuries in the elderly resulted in an in-hospital mortality rate double that of younger patients and that there was a significantly higher rate of chest injuries. On a population basis, overall road traffic fatality rates for the elderly were almost double that of the younger group.

Most of the research in this area has been performed in the US. Compared to the US,<sup>14</sup> Victoria has a lower fatality rate. Although the rates were lower, most of the trends seen in the US were also reflected in our data. Male involvement was significantly greater than that of female involvement across all age groups. Interestingly, similar to the US trend, elderly females had a sharp increase in fatality rate. The fatality rate of the elderly female was almost three times that of the younger female.

The US motor vehicle collision fatality data for the elderly showed death was mainly due to motor vehicle occupants rather than pedestrians.<sup>15</sup> A similar trend was shown in our study. In major trauma patients who survived to hospital, the total mortality rate of the elderly group involved was 26.4%, with driver mortality and passenger mortality both at 27.16% and pedestrian mortality at 25%. Given that two thirds were motor vehicle occupants and they generally have a higher mortality rate, the question of limiting the elderly from

**Table 3** AIS body region versus age

Body region	<65 years		≥65 years		Total	p Value
	n	%	n	%		
Abdomen or pelvic content	491	11.54	44	8.18	535	0.023
Chest	773	18.17	126	23.42	899	0.003
External	829	19.49	100	18.59	929	0.66
Extremities or pelvic gird	824	19.37	116	21.56	940	0.25
Face	394	9.26	29	5.39	423	0.003
Head or neck	943	22.17	123	22.86	1066	0.75
Total	4254	100	538	100	4792	

**Table 4** Involvement of the body region versus age group in different collision type

Body region	Motor vehicle drivers					Motor vehicle passenger					Pedestrians				
	<65 years		≥65 years		p Value	<65 years		≥65 years		p Value	<65 years		≥65 years		p Value
	n	%	n	%		n	%	n	%		n	%	n	%	
Abdomen and pelvic content	197	11.10	19	7.76	NS	100	6.72	17	9.71	NS	57	9.15	7	4.43	NS
Chest	331	18.66	65	26.53	0.004	142	9.54	31	17.71	0.001	84	13.48	26	16.46	NS
External	350	19.73	47	19.18	NS	350	23.52	47	26.86	NS	127	20.39	33	20.89	NS
Pelvic and extremities	332	18.71	51	20.82	NS	332	22.31	51	29.14	0.05	135	21.67	40	25.32	NS
Face	186	10.48	15	6.12	0.043	186	12.50	6	3.43	<0.001	64	10.27	7	4.43	0.03
Head and neck	378	21.31	48	19.59	NS	378	25.40	23	13.14	>0.001	156	25.04	45	28.48	NS
Total	1774	100.00	245	100.00		1488	100.00	175	100.00		623	100.00	158	100.00	

NS, not significant.

driving arises. This might include stringent licensing criteria for the older population. This does not appear to be a viable option as our elderly population is becoming more independent. In US studies, there was no significant increase in collision rate as the age increased.<sup>6, 16</sup> As people age, it is presumed that they adopt a safer driving practice: the elderly travel fewer miles, slower, mainly in the day, and are involved in fewer alcohol related road accidents. These measures offset some of the handicaps that they face, such as poor eyesight, poor hearing, and reduced reflex time. Often older drivers elect to stop driving when their competency reduces with age.<sup>17</sup> However, the increased fragility of the aging body cannot be offset. Thus we should look more into safer cars and safety measures for the elderly motor vehicle users.

The inhospital mortality of the elderly group was more than double that of the younger group. Studies have shown that there is a direct correlation between mortality and increase in age, regardless of the injury severity score.<sup>18, 19</sup> Thus, the allocation of high cost treatment to this group is sometimes questioned. Most elderly patients do have a good outcome, especially if they do not have significant comorbidity before the injury.<sup>20–22</sup> The majority of elderly victims of road collisions should be of reasonable health pre-injury, because all of them were able to travel. Thus aggressive post injury care is usually indicated in the elderly population.

The elderly group had significantly higher rates of chest injuries compared with other regions of the body. This was especially true for motor vehicle occupants. Most of the chest injuries were of the chest wall, namely rib fractures, flail chest, and sternum fractures. Elderly victims with chest injuries had significantly longer intensive care unit stays compared with the young. There was a higher mortality rate

in the elderly group with chest injuries (old, 25.87% v young, 20.14%,  $p = 0.18$ ) but it was not statistically significant.

Chest wall injuries have been associated with seatbelt usage. This becomes more significant in the elderly due to osteoporosis, exaggerated thoracic kyphosis, decreased muscle mass, thinning of the intervertebral discs, shortening of the vertebral bodies, and decreased chest wall compliance.<sup>23</sup> Chest injuries in the elderly were associated with increased morbidity and mortality, in particular rib fractures. This was found to be significant even after taking into account comorbidities.<sup>24</sup> In the elderly, the number of rib fractures has been correlated with increased mortality and risk of pneumonia.<sup>25</sup> This is of importance as radiological evidence of chest wall fractures is easily missed and often not visible. Doctors treating the elderly for motor vehicle collision should take into consideration their higher risk for chest injuries. Early recognition and aggressive management can reduce complications and give better outcome for this increasingly large group of patients.

Seatbelt usage increases the number of chest injuries in the elderly but it also reduces the total morbidity and mortality of the occupant compared to an unbelted person.<sup>26</sup> Thus, further research into improvement of the design of motor vehicles should take into consideration the fragility of the elderly. Newer safety measures such as depowered airbags, inflatable belt restraints, and side protection should be introduced if they prove to reduce chest injuries in the elderly.

There was a higher rate of face, head, and neck injuries in the younger patients. A possible explanation might be that younger motor vehicle occupants did not use seat belts, resulting in forward thrust during a collision and higher rate of injury. Spinal injuries were also noted to be significantly higher in the younger population. It is possible that young

**Table 5** Type of chest injuries in young and elderly groups

Injury description	<65 years	%	≥65 years	%	total	p Value
Single rib fracture	66	3.32	9	2.69	75	NS
Multiple ribs fracture	303	15.25	70	20.90	373	0.01
Flail chest	72	3.62	32	9.55	104	<0.001
Sternum	47	2.37	20	5.97	67	<0.001
Cardiac	42	2.11	9	2.69	51	NS
Diaphragm	35	1.76	6	1.79	41	NS
Lung	401	20.18	64	19.10	465	NS
Pleural	496	24.96	85	25.37	581	NS
Spine	432	21.74	22	6.57	454	<0.001
Vessel	22	1.11	4	1.19	26	NS
Others	63	3.17	12	3.58	75	NS
Wrong	8	0.40	2	0.60	10	
Total	1987	100.00	335	100.00	2322	

NS, not significant.



people have a more compliant chest wall and better musculature. Hence, forces are transmitted by the seatbelt to the spine and result in spinal injuries. Another possibility may be difficulty in differentiating acute spinal fracture from old osteoporotic fractures in the elderly patients. Thus spinal injuries may be underdiagnosed in the elderly group.

For head and neck injuries, both the elderly and young group had similar AIS severity and no significant difference in presenting GCS. However, the operative rate for the elderly group was much lower. In Scotland, it was noted that age appears to be an independent factor in trauma care, with significantly more of the elderly patients dying than would be predicted.<sup>27</sup> With this in mind we did an analysis of mortality by AIS region between the two groups. There was no difference in the mortality rate of head and neck injured patients between the elderly and the young.

Our study has several limitations. The data used for injury pattern do not take into account the people who did not present to hospital, such as those who died at the scene or suffered minor injuries that did not require hospital care. Other limitations include possible missed motor vehicle collisions in database reporting (estimated to be less than 10%)<sup>10</sup> and lack of sufficient information about the comorbidities status of the patient beside that documented on discharge data. The functional status of patient on discharge and beyond was not available for this study.

## CONCLUSION

Elderly road users have a higher fatality rate when involved in motor vehicle accidents, especially elderly females. Most of the inhospital mortality in the elderly victims had been motor vehicle occupants. They are more likely to suffer from chest injuries compared with the younger population, especially chest wall fractures.

This study highlights the high fatality rate, different pattern of injury, and implications for injury prevention and management in the elderly.

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## Authors' affiliations

**W Y Yee, P A Cameron**, Emergency and Trauma Centre, The Alfred Hospital, Commercial Road, Prahran, Victoria, Australia  
**P A Cameron, M J Bailey**, National Trauma Research Institute and Department of Epidemiology of Preventive Medicine, Monash University, Victoria, Australia

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